Biosignatures alteration under proton irradiation studied in situ by Raman spectroscopy: relevance for the search for life on Mars

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More than 3.5 billion years ago, the surface of Mars experienced habitable conditions compatible, with the presence of liquid water in particular. Primitive microbial life may thus has appear and develop at that time and biological remains may still be present at the surface of the red planet [1,2].

Nevertheless, the surface of Mars has been continuously exposed to high-energy UV radiation (down to 190 nm wavelength), deleterious for organics [1,3]. Moreover, in the absence of a magnetic field, it is also exposed to the solar and galactic cosmic rays that reach the surface and the near subsurface [4]. In addition to making the surface of Mars presently inhospitable, this radiative environment may have altered putative biosignatures over time. The European Space Agency's ExoMars mission, now scheduled for 2028, will therefore explore the subsurface of Mars, down to 2 m deep, in order to increase the chances of detecting well preserved molecules. In particular, the rover is equipped with a Raman spectrometer that could can detect both organic and mineral phases and is thus particularly relevant to search for past or present traces of life [5-7].

In order to evaluate the effect of particle irradiation on the Raman signal of biosignatures, we irradiated molecules of exobiological interest, mixed with or protected by analogous mineral matrices from Mars, with 2.8 MeV protons on the Pelletron of the CEMHTI laboratory at the CNRS in Orléans. A new device called RAMSESS (for RAMan SpEctroscopy for in Situ Studies), was used to study the changes in the Raman signal in situ within the irradiation chamber [8]. Using models, we were able to compare the dose received by the samples during irradiation at Pelletron with that received on Mars, with depth and time. These results are relevant in the framework of the ExoMars mission and are very complementary to those obtained during the BIOMEX experiment on-board the ISS [9,10].

References: [1] J.-P. Bibring et al., Science 312, 400 (2006). [2] F. Westall, et al., Astrobiology 15, 998 (2015). [3] M. A. Bullock et al., Icarus 107, 142 (1994). [4] G. de Angelis et al., Adv. Space Rese. 34, 1328 (2004). [5] F. Foucher, in Biosignatures for Astrobiology, Cavalazzi, B., Westall, F. (Eds.), Springer, (2019). [6] F. Foucher & F. Westall, Astrobiology 13:1, 57 (2013). [7] F. Foucher et al., J. Raman Spec. 46, 873 (2015). [8] A. Canizarès et al., Applied Spec. 76, 723 (2022). [9] J.-P. de Vera et al., Astrobiology 19:2, 145 (2019). [10] M. Baqué et al., Sci. Adv. 8, 36 (2022).